[0082] In other words, each pixel of the line-space image corresponds to a line such as the first line **910***a*, second line **910***b*, and third line **910***c* overlaid on the 2D point map and each pixel has a pixel value corresponding to a number of points of the 2D point cloud represented by the line.

[0083] FIG. **9**B illustrates an example line-space image **902** based on the point cloud represented in FIG. **5**. The line-space image **902** includes a first peak **911***a* at a pixel location corresponding to the first line **910***a* of FIG. **9**A. The line-space image **902** includes a second peak **911***b* at a pixel location corresponding to the second line **910***b* of FIG. **9**A. The line-space image **902** includes a third peak **911***c* at a pixel location corresponding to the third line **910***c* of FIG. **9**A.

[0084] In various implementations, the device generates the line-space image by performing a Hough transform of unpaired points of the point cloud (e.g., projected onto a 2D point map). The line-space image generated by the Hough transform may then be modified based on paired points of the point cloud.

[0085] In various implementations, the device generates the line-space image using Monte Carlo sampling of pairs of points. For example, the device: (1) selects two points of the point cloud, (2) determines two parameters of a line projected to the common height in the gravity-aligned coordinate system defined by the two points (e.g., determines the slope and intercept or the distance and angle), and (3) increments, by an amount, a pixel value of a pixel of the line-space image corresponding to the two parameters. The device does this repeatedly a large number of times until the line-space image converges. In various implementations, selecting the two points includes randomly selecting two unpaired points of the points. In various implementations, selecting the two points includes selecting two paired points of the point cloud, in which case the pixel value is incremented by the amount scaled by a length of the line. Thus, in some sense, the line-space image is also a two-dimensional histogram of respective lines, each dimension being one parameter of a two-parameter representation of the line and the amount at each bin being representative of the number of lines through points of the points cloud having such a two-parameter representation.

[0086] In various implementations, when the points are associated with respective uncertainties, generating the line-space image using Monte Carlo samples includes (1) selecting two points of the point cloud, (2) determining two parameters of a line projected to the common height in the gravity-aligned coordinate system defined by the two points, (3) determining a probability distribution of the two parameters based on the two parameters and the respective uncertainties of the two points, and (4) increasing, by an amount, pixel values of a plurality of pixels of the line-space image corresponding to the probability distribution of the two parameters. In various implementations, selecting the two points includes randomly selecting two unpaired points of the points. In various implementations, selecting the two points includes selecting two paired points of the point cloud, in which case the pixel value is increased by the amount scaled by a length of the line.

[0087] The method **800** continues, at block **806**, with the device generating one or more vertical plane hypotheses based on the line-space image. In various implementations, generating the one or more vertical plane hypotheses includes generating one or more sets of planar coefficients, each set defining a vertical plane (e.g., parallel to the gravity vector).

[0088] In various implementations, the device thresholds the line-space image and generates a vertical plane hypothesis for each pixel in the line-space image having a pixel value that is above a threshold. Thus, in various implementations, generating the one or more vertical plane hypotheses includes determining that one or more pixel values are greater than a threshold and generating one or more vertical plane hypotheses corresponding to the one or more pixel values greater than the threshold. For example, with reference to FIG. **9**B, the device generates a first plane hypothesis corresponding to the first peak **911***a* (corresponding to the first line **910***a*, the first cluster of points **916**, and the side wall **406**) and a second plane hypothesis corresponding to the third peak **911***c* (corresponding to the third line **910***c*, the second cluster of points **917**, and the back wall **407**).

[0089] In various implementations, the device generates the one or more vertical plane hypotheses by detecting one or more peaks in the line-space image and generating one or more vertical plane hypotheses corresponding to the peaks. In various implementations, in detecting the one or more peaks, the device applies non-maxima suppression algorithm to the line-space image.

[0090] While various aspects of implementations within the scope of the appended claims are described above, it should be apparent that the various features of implementations described above may be embodied in a wide variety of forms and that any specific structure and/or function described above is merely illustrative. Based on the present disclosure one skilled in the art should appreciate that an aspect described herein may be implemented independently of any other aspects and that two or more of these aspects may be combined in various ways. For example, an apparatus may be implemented and/or a method may be practiced using any number of the aspects set forth herein. In addition, such an apparatus may be implemented and/or such a method may be practiced using other structure and/or functionality in addition to or other than one or more of the aspects set forth herein.

[0091] It will also be understood that, although the terms "first," "second," etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first node could be termed a second node, and, similarly, a second node could be termed a first node, which changing the meaning of the description, so long as all occurrences of the "first node" are renamed consistently and all occurrences of the "second node" are renamed consistently. The first node and the second node are both nodes, but they are not the same node.

[0092] The terminology used herein is for the purpose of describing particular implementations only and is not intended to be limiting of the claims. As used in the description of the implementations and the appended claims, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term "and/or" as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers,